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New Method for Cuttings-Based Prediction of Stratigraphic Seal Capacity

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ABSTRACT

Seals for many stratigraphic traps are capillary seals. Prediction of seal capacity is difficult and rarely validated. Ideally, laboratory testing of core samples is required to determine seal capacity, and even this remains a challenge because of long measurement times and core damage. The latter requires that flow experiments are performed under in-situ stresses and that sufficient time is given for pressure equilibration (several days) in order to close artificial fractures efficiently. Prediction based on Mercury injection porosimetry is also problematic and not always reliable, especially when soft materials like clays/mudrocks are tested [1,2]. As a consequence, worldwide correlations have been used to forecast the capillary / hydraulic sealing efficiency. We developed a cap seal database relating macroscopic petrophysical properties such as porosity and clay content to capillary breakthrough pressure [3,4].

Different analyses for characterization of the pore geometry are required. We use BIB-SEM (Broad Ion Beam Milling and Scanning Electron Microscopy) which can help estimate capillary breakthrough pressure

in small samples (irregular shaped cuttings) as it allows accurate quantification of the pore space from cm to nm-scale resolution. It thus provides a range of new insights on pore properties, especially in finegrained

and tight rocks [5,6,7]. Image segmentation enables efficient correlation of the pore size distributions to bulk measurements or log data. One way do derive a value for permeability is to use capillary tube models, which may return calculated permeability coefficient within one order of magnitude compared to experimental measurements. Connected porosity can be shown in 2D by Liquid Metal Injection (LMI) followed by BIB-SEM [2]. BIB-SEM under cryogenic conditions [8,9] was used to assess the impact of drying/drilling damage and mud invasion on the microstructure in fresh cuttings prior to the analysis using this comprehensive imaging toolbox. This opens the door for using cuttings which are abundant. By differentiation of pores structures, i.e. artificial fractures versus natural existing pores, we are able to predict capillary sealing efficiency of sealing formations.

The above mentioned techniques can be used to further evaluate the results obtained from petrophysical measurements on plugs (under confinement) and on cuttings (GRI - ambient). While these methods provide valuable quantitative information on permeability and capillary breakthrough pressure as function of different boundary conditions, optical analyses help to understand which lithological feature is most

important for transport or capillary sealing. This way, petrophysical properties could be directly coupled to distinct lithological micro-facies, providing a tool for upscaling to different inhomogeneous/stratified lithotypes.